

PRELIMINARY DATA SUMMARY

April 1991

U.S. Army Engineer Waterways Experiment Station
Coastal Engineering Research Center
Field Research Facility
Duck, North Carolina

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CERC Field Research Facility
Duck, North Carolina

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

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PART I: INTRODUCTION

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.6 m above the National Geodetic Vertical Datum (NGVD). In addition, a main building contains offices, an instrument repair shop, and a data acquisition room.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local oceanographic and meteorological conditions. Bottom profiles along both sides of the pier and periodic bathymetric surveys are also performed.

This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Michael W. Leffler at (919) 261-3511.

Part II presents the meteorological data; Parts III through VI present oceanographic data; Part VII presents nearshore profiles and bathymetry; and Part VIII, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used, their operational status during the month, and the data collection status. Figure 2 identifies the location of the instruments. The water depths at the wave gages and current meters vary and may be determined from information contained in Figure 7. Other installation information is contained in Table 1.

Times given in the report, unless otherwise specified, are referenced to eastern standard time (EST).

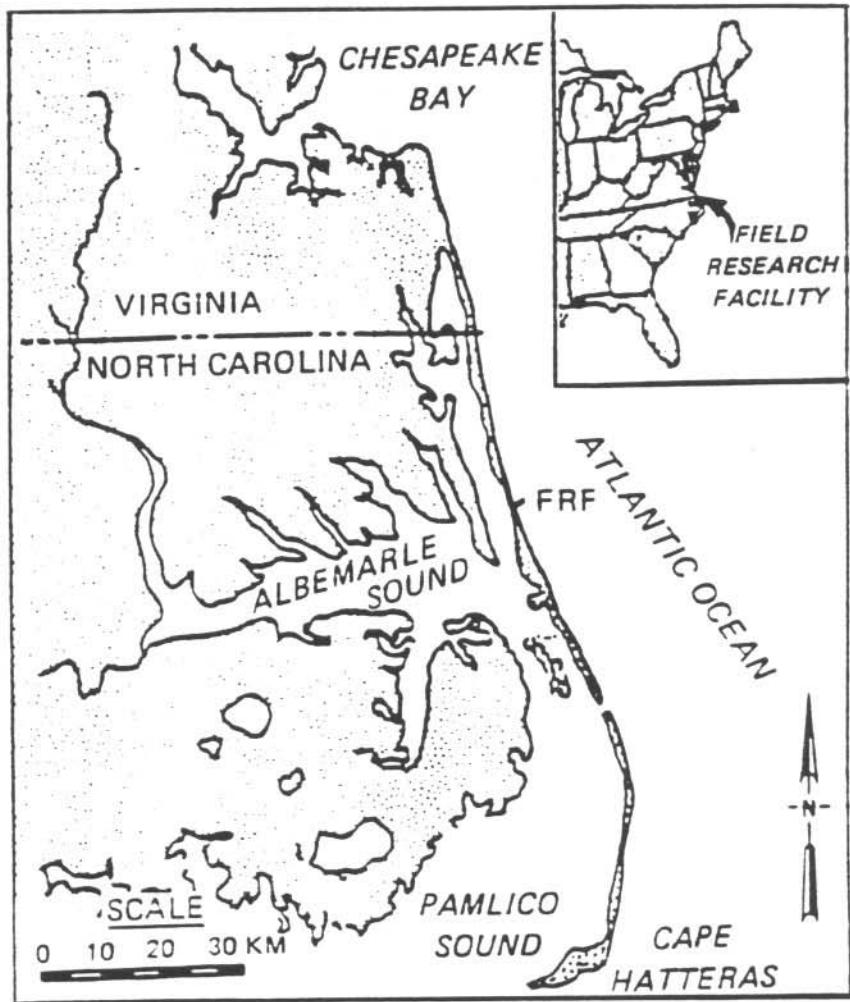


Figure 1. FRF location map

Table 1: Instrument Status/Data Availability

APR 1991

Gage ID	Description/Remarks	Depth at Sensor		Day of the month																																
				1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0			
616	Barometric Pressure		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
604	Precipitation		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
624	Air Temperature		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
932	Anemometer at seaward end of pier Elevation 19 m (NGVD)		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
645	Baylor staff at station 7+80 on FRF pier	see Figure 7	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
625	Baylor staff at station 18+60 on FRF pier	see Figure 7	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
111	Pressure gage 309 m north of FRF pier (0.9 km offshore)	Approx. 7.8 m NGVD	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
630	Waverider buoy 6.0 km offshore	Approx. 23 m NGVD	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
519	Current meter 320 m north of FRF pier (0.9 km offshore)	see Figure 7	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
865-1370	NOAA tide station at seaward end of FRF pier		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Supplemental Observations (daily oceanographic and meteorological observations)				Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	

Gage Status	Daily Observation	Analog Record	Data Collected
Operational = *	Complete = *	Complete = *	All = *
Partial = /	Partial = /	Partial = /	Partial = /
Non-Operational = -	None = -	None = -	None = -

True North

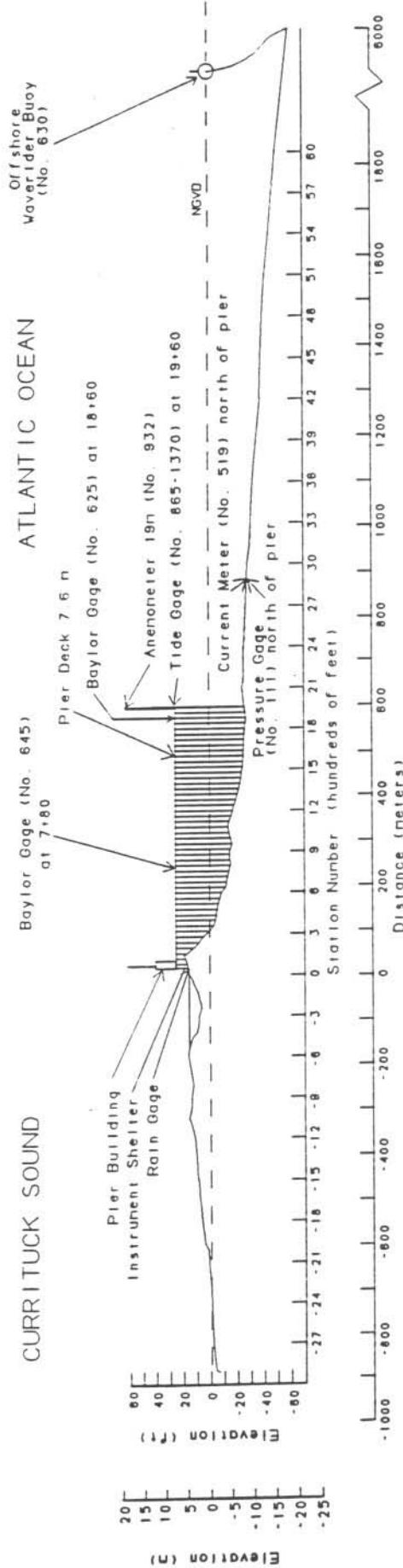
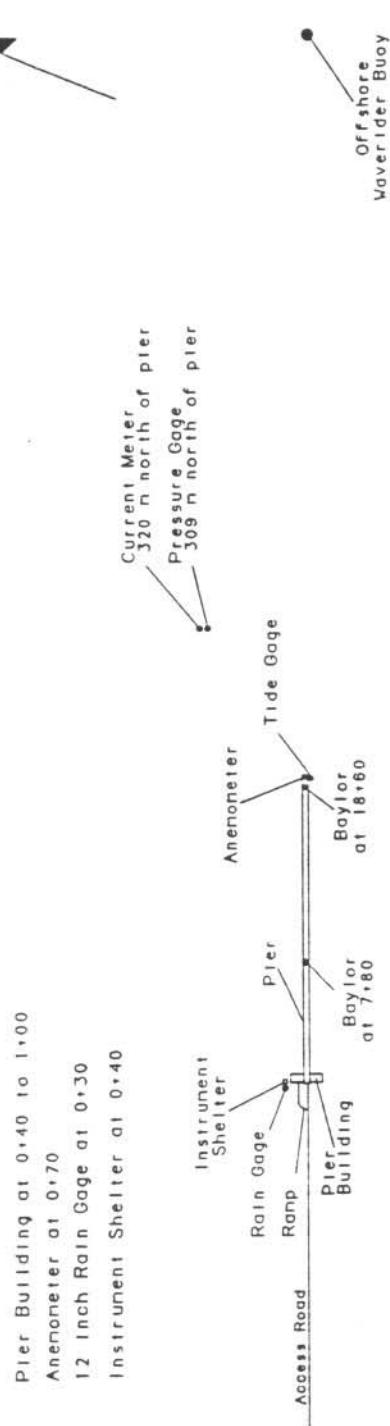



Figure 2. Instrument locations at FRF (all elevations from NGVD, all distances from FRF baseline).

PART II: METEOROLOGICAL DATA

A variety of instruments have been installed at the FRF (Figure 2) to monitor the meteorological conditions. The data presented in Table 2 are collected and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1 as having analog outputs, chart records are obtained, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 2) using a Weather Measure Skyvane anemometer.

Monthly resultant wind speeds and directions are determined by vector averaging the data. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 2 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -
 $m/s \times 1.943 = kn$

Table 2: Meteorological Data

Apr 1991

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	5	324	6.0	1014.2	0
	700	4	262	9.6	1014.8	0
	1300	6	256	16.4	1013.8	0
	1900	2	89	12.6	1016.2	0
2	100	6	8	9.6	1019.2	0
	700	4	45	10.0	1021.6	0
	1300	5	88	13.2	1021.9	0
	1900	5	57	9.9	1024.0	0
3	100	7	21	9.3	1027.0	0
	700	8	23	9.2	1030.4	0
	1300	6	16	10.4	1031.8	0
	1900	6	76	8.1	1030.7	0
4	100	5	69	8.7	1030.7	0
	700	4	83	10.6	1031.4	0
	1300	4	73	14.1	1030.4	0
	1900	6	137	11.4	1028.0	0
5	100	5	159	11.7	1026.7	0
	700	4	189	14.9	1026.0	0
	1300	7	209	21.2	1022.6	0
	1900	4	200	17.2	1019.9	0
6	100	5	249	15.4	1018.6	0
	700	4	273	15.1	1018.2	3
	1300	2	107	20.2	1017.9	0
	1900	6	149	14.8	1016.5	0
7	100	7	214	15.7	1015.9	0
	700	5	244	16.3	1016.9	0
	1300	4	232	25.6	1015.9	0
	1900	6	202	20.6	1014.5	0
8	100	6	210	17.5	1015.9	0
	700	5	219	18.4	1016.9	0
	1300	6	222	26.4	1015.2	0
	1900	9	206	21.5	1013.1	0
9	100	9	218	20.1	1013.1	0
	700	9	223	20.6	1012.8	0
	1300	7	221	26.2	1010.4	0
	1900	9	199	21.1	1008.1	0
10	100	8	213	20.2	1007.4	0
	700	6	236	19.4	1008.7	0
	1300	6	249	23.3	1008.4	0
	1900	4	255	21.1	1009.1	0
11	100	11	7	12.4	1014.8	0
	700	13	357	9.3	1021.6	0
	1300	8	8	11.7	1023.3	0
	1900	4	125	10.0	1023.3	0
12	100	2	170	8.6	1024.7	0
	700	11	30	11.1	1028.4	0
	1300	9	20	10.4	1030.7	0
	1900	7	52	9.5	1030.7	0
13	100	7	65	10.6	1029.4	0
	700	6	40	10.9	1028.0	0
	1300	7	133	14.7	1025.3	0
	1900	8	195	16.4	1021.3	0
14	100	5	223	16.6	1018.9	0
	700	6	26	11.9	1020.3	0
	1300	7	355	11.9	1021.3	0
	1900	8	47	12.1	1019.9	0
15	100	6	355	12.5	1017.9	0
	700	1	186	13.2	1017.2	0
	1300	9	206	25.4	1013.1	0
	1900	6	189	20.6	1012.1	4
16	100	8	221	19.5	1012.1	0
	700	7	336	17.0	1014.5	9
	1300	3	36	16.8	1016.2	0
	1900	1	42	14.5	1015.9	0

* electronic problems

(Continued)

(Sheet 1 of 2)

Table 2: Meteorological Data

Apr 1991

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
17	100	4	152	15.1	1015.2	0
	700	2	190	18.9	1014.8	0
	1300	3	138	21.5	1012.1	0
	1900	6	198	20.7	1009.8	0
18	100	4	287	19.4	1009.1	0
	700	12	18	11.2	1010.8	0
	1300	13	11	11.5	1013.1	0
	1900	12	21	9.4	1014.8	0
19	100	12	28	9.6	1014.5	0
	700	11	42	10.2	1015.5	0
	1300	9	26	11.7	1014.8	0
	1900	9	34	12.2	1011.8	0
20	100	7	39	12.5	1009.1	0
	700	9	58	13.2	1005.7	7
	1300	5	342	13.9	1001.6	20
	1900	19	2	11.7	999.9	2
21	100	13	336	10.8	998.6	2
	700	8	313	10.0	999.3	18
	1300	5	262	13.1	997.6	0
	1900	5	280	10.7	997.2	0
22	100	8	287	9.2	998.2	4
	700	8	277	9.6	1001.3	0
	1300	7	252	15.0	1001.3	0
	1900	8	256	14.7	1003.3	0
23	100	6	266	12.8	1006.4	0
	700	2	270	13.1	1010.4	0
	1300	7	127	17.2	1010.1	0
	1900	5	113	12.8	1008.7	0
24	100	1	85	12.3	1007.0	0
	700	3	204	15.5	1008.1	0
	1300	7	204	23.0	1005.4	0
	1900	7	295	19.3	1007.0	0
25	100	11	320	11.9	1013.8	0
	700	9	327	12.8	1016.5	0
	1300	4	26	14.3	1018.6	0
	1900	3	139	12.0	1018.2	0
26	100	2	152	11.2	1018.6	0
	700	1	66	14.3	1019.2	0
	1300	2	45	16.7	1018.9	0
	1900	4	148	14.2	1017.9	0
27	100	3	170	14.5	1016.5	0
	700	4	200	18.4	1016.2	0
	1300	4	168	24.8	1014.8	0
	1900	8	190	20.5	1013.5	0
28	100	5	193	19.0	1012.5	0
	700	4	150	15.0	1013.1	0
	1300	7	134	16.5	1013.5	4
	1900	4	105	15.8	1013.5	0
29	100	2	353	15.1	1013.5	0
	700	7	343	15.3	1015.5	0
	1300	4	353	18.4	1015.5	0
	1900	4	51	16.8	1015.2	0
30	100	3	190	18.1	1015.5	0
	700	4	202	21.2	1014.2	0
	1300	5	234	27.5	1013.1	0
	1900	9	186	22.3	1012.5	0
		Resultant 1	329	Mean 15.1	Mean 1015.5	Total 73

* electronic problems

(Sheet 2 of 2)

PART III: WAVE DATA

Wave data are collected from two Baylor staff gages (Gages 625 and 645), a pressure wave gage (Gage 111) and a Waverider buoy (Gage 630) as shown in Table 1 and Figure 2. The data are collected, analyzed, and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750 programmed to sample the wave gages every 6 hr (more frequently during storms) beginning at 0100, 0700, 1300, and 1900 EST. The sampling rate is two times per second for four contiguous 34-min records.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gage has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to magnetic tape.

Table 3 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 3 are average values computed from this data. Figure 3 is a time history of all H_{mo} and T_p values obtained for all gages.

Differences in wave periods between wave gages (Table 3 and Figure 3) may be the result of wave breaking, wave reformation, or the presence of multiple wave trains containing nearly equal energy.

Table 3: Wave Data

Apr 1991

Day	Hour	645		625		111		630	
		Baylor at 7+80	Hmo.m T.sec	Baylor at 18+60	Hmo.m T.sec	Pressure Gage	Hmo.m T.sec	Offshrd Wvrdr	Hmo.m T.sec
1	0100	0.81	5.12	1.07	8.00	1.11	5.69	1.13	5.95
	0700	0.88	8.26	1.07	8.26	1.20	7.76	1.13	8.00
	1300	0.69	9.85	0.86	9.85	0.93	9.85	0.80	7.76
	1900	0.56	8.00	0.69	10.24	0.72	7.76	0.67	8.00
2	0100	0.47	9.14	0.71	9.48	0.70	9.48	0.71	9.14
	0700	0.82	3.82	0.89	8.53	0.92	9.14	0.94	8.53
	1300	0.38	9.14	0.68	7.31	0.66	9.48	0.67	9.14
	1900	0.57	3.66	0.68	8.26	0.65	7.11	0.72	7.76
3	0100	0.45	9.85	0.62	9.14	0.56	8.53	0.64	8.26
	0700	0.67	3.01	0.82	9.48	0.72	8.53	0.81	9.14
	1300	0.44	9.48	0.66	8.53	0.60	9.48	0.65	8.83
	1900	0.53	8.83	0.64	8.83	0.61	8.53	0.65	8.83
4	0100	0.55	4.74	0.62	10.24	0.64	8.83	0.62	8.00
	0700	0.41	10.67	0.69	11.13	0.67	10.67	0.68	5.45
	1300	0.32	11.13	0.62	11.13	0.59	11.13	0.64	10.24
	1900	0.38	10.67	0.65	11.13	0.59	11.13	0.69	10.67
5	0100	0.42	11.13	0.54	10.67	0.54	10.24	0.59	11.13
	0700	0.38	11.13	0.53	11.13	0.53	11.13	0.60	10.67
	1300	0.32	10.67	0.50	11.13	0.53	11.13	0.61	10.67
	1900	0.31	10.67	0.55	10.67	0.50	10.67	0.60	10.24
6	0100	0.33	10.24	0.41	10.24	0.47	10.67	0.56	10.67
	0700	0.29	10.67	0.42	9.85	0.44	10.67	0.55	9.14
	1300	0.35	10.24	0.41	10.24	0.49	9.85	0.63	6.40
	1900	0.24	9.85	0.47	9.48	0.48	9.48	0.58	6.56
7	0100	0.33	9.85	0.44	9.85	0.48	9.48	0.54	9.85
	0700	0.25	9.85	0.40	9.48	0.43	9.48	0.52	9.14
	1300	0.25	8.83	0.36	8.53	0.38	9.14	0.43	9.48
	1900	0.27	9.48	0.38	8.83	0.38	9.48	0.47	8.83
8	0100	0.27	9.14	0.33	9.14	0.38	9.14	0.46	9.48
	0700	0.23	9.14	0.33	9.48	0.37	8.83	0.41	9.14
	1300	0.27	9.14	0.33	8.83	0.35	9.14	0.42	8.53
	1900	0.27	9.14	0.43	8.83	0.41	8.83	0.54	8.53
9	0100	0.28	8.83	0.32	8.83	0.38	9.14	0.60	8.83
	0700	0.27	6.09	0.44	8.83	0.48	6.24	0.73	6.40
	1300	0.40	6.24	0.46	6.40	0.52	5.95	0.70	6.09
	1900	0.34	4.41	0.55	9.14	0.55	8.83	0.81	4.92
10	0100	0.39	8.53	0.43	8.53	0.51	8.53	0.83	6.74
	0700	0.24	8.83	0.45	7.11	0.47	6.92	0.73	7.76
	1300	0.28	7.53	0.37	8.83	0.38	8.83	0.53	8.53
	1900	0.29	7.53	0.35	8.53	0.39	8.26	0.50	6.56
11	0100	0.68	3.37	0.75	3.37	0.53	3.41	0.78	3.20
	0700	1.34	6.40	1.64	6.24	1.79	6.24	2.05	6.24
	1300	1.06	6.24	0.95	6.92	1.07	6.40	1.46	5.12
	1900	0.65	6.09	0.59	6.56	0.60	6.74	0.86	5.82
12	0100	0.32	5.82	0.49	7.53	0.53	7.31	0.59	8.00
	0700	0.64	2.67	0.57	2.48	0.46	6.56	0.56	6.40
	1300	1.02	6.56	1.41	6.40	1.44	6.40	1.73	6.24
	1900	1.12	6.24	1.00	6.56	1.06	6.56	1.27	6.09
13	0100	0.95	6.24	1.14	5.12	1.18	5.22	1.37	5.57
	0700	1.01	5.69	0.98	5.82	0.97	5.69	0.99	6.09
	1300	0.79	6.24	0.87	6.24	0.84	5.95	0.95	5.95
	1900	0.78	5.22	0.89	7.76	0.94	7.76	0.98	7.53
14	0100	0.64	6.24	0.80	6.56	0.84	6.40	0.93	6.24
	0700	0.58	5.95	0.73	5.82	0.73	5.82	0.84	5.57
	1300	0.59	3.28	0.62	5.69	0.64	10.67	0.71	6.40
	1900	1.32	7.31	1.31	7.11	1.52	7.31	1.56	7.11
15	0100	0.96	9.14	1.44	9.48	1.46	9.14	1.41	9.14
	0700	1.21	7.76	1.37	12.80	1.41	8.83	1.42	8.00
	1300	0.99	5.22	1.12	11.64	1.15	11.64	1.17	8.53
	1900	0.64	9.85	0.92	9.85	0.87	9.85	1.09	9.48
16	0100	0.59	9.14	0.70	9.14	0.72	9.14	1.02	8.83
	0700	0.53	8.53	0.65	8.83	0.73	8.26	0.94	6.09
	1300	0.45	6.92	0.52	9.48	0.57	8.26	0.71	8.00
	1900	0.43	4.34	0.59	9.14	0.66	7.76	0.76	7.53

* Electronic problems

(Continued)

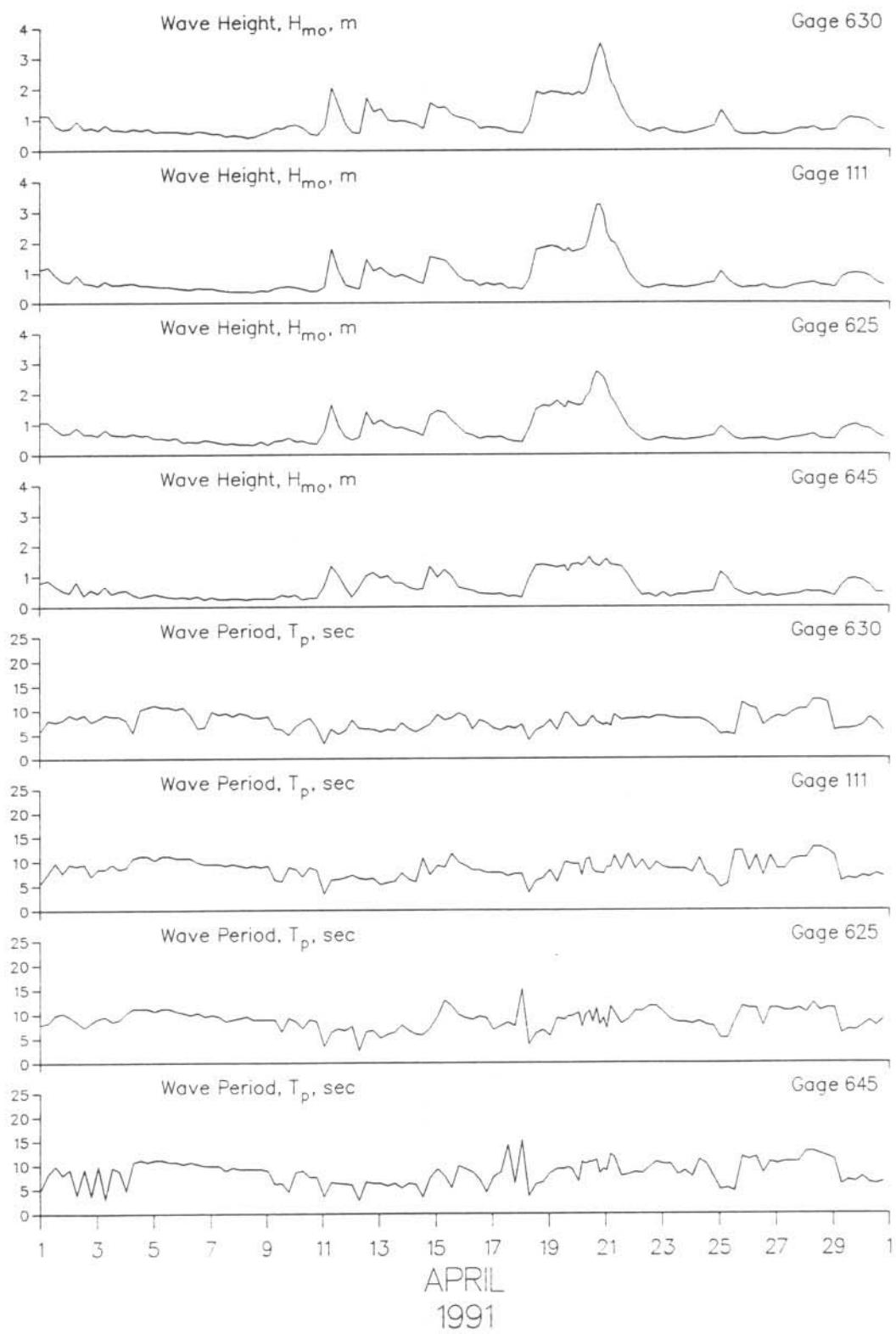
Table 3: Wave Data

Apr 1991

Day	Hour	645		625		111		630	
		Baylor at 7+80	Hmo.m T.sec	Baylor at 18+60	Hmo.m T.sec	Pressure Gage	Hmo.m T.sec	Offshrd Wvrdr	Hmo.m T.sec
17	0100	0.41	7.53	0.57	6.74	0.59	7.76	0.74	6.40
	0700	0.42	8.53	0.59	7.53	0.64	7.76	0.71	5.95
	1300	0.34	14.22	0.47	8.26	0.48	7.11	0.60	6.74
	1900	0.35	6.24	0.43	7.53	0.49	7.53	0.59	6.24
18	0100	0.31	15.06	0.42	15.06	0.45	7.53	0.55	7.11
	0700	0.92	3.56	0.85	3.71	0.79	3.56	0.91	3.77
	1300	1.35	5.95	1.50	6.09	1.75	6.09	1.92	5.95
	1900	1.37	6.40	1.61	6.74	1.81	6.56	1.83	6.56
19	0100	1.34	8.26	1.58	5.57	1.89	8.26	1.91	8.00
	0700	1.28	9.14	1.76	9.14	1.84	5.82	1.90	5.95
	1300	1.33	9.14	1.53	8.83	1.70	9.85	1.83	9.48
	1900	1.37	9.14	1.66	9.48	1.68	9.48	1.78	8.53
20	0100	1.40	6.56	1.60	10.24	1.73	9.48	1.90	6.74
	0700	1.44	10.24	1.89	9.85	1.87	10.24	1.91	6.92
	1300	1.45	10.67	2.43	8.26	2.76	8.26	2.81	8.83
	1900	1.31	8.26	2.63	7.76	3.23	7.76	3.49	7.31
21	0100	1.54	8.83	2.26	6.92	2.28	8.83	2.70	7.31
	0700	1.35	11.64	1.70	10.24	1.98	11.13	2.04	9.14
	1300	1.33	7.76	1.27	8.00	1.52	8.26	1.45	8.00
	1900	1.03	8.00	0.89	8.83	0.99	11.64	1.03	8.26
22	0100	0.67	8.53	0.67	10.67	0.70	8.53	0.77	8.26
	0700	0.38	8.26	0.50	10.67	0.52	10.24	0.68	8.53
	1300	0.41	9.48	0.42	11.64	0.48	8.00	0.58	8.26
	1900	0.30	10.67	0.49	11.64	0.55	9.85	0.68	8.83
23	0100	0.47	10.24	0.56	10.24	0.58	8.83	0.71	8.83
	0700	0.31	10.24	0.50	8.83	0.54	8.53	0.61	8.53
	1300	0.40	8.00	0.48	8.26	0.52	8.53	0.55	8.26
	1900	0.40	8.83	0.47	8.26	0.50	8.53	0.54	8.26
24	0100	0.44	7.53	0.49	8.00	0.54	7.76	0.58	8.26
	0700	0.46	11.13	0.52	8.53	0.57	10.67	0.64	8.26
	1300	0.49	10.24	0.57	7.76	0.63	7.53	0.70	7.76
	1900	0.50	7.53	0.60	7.53	0.66	6.74	0.78	6.56
25	0100	1.13	4.83	0.91	5.12	1.02	4.57	1.30	5.02
	0700	0.93	5.22	0.71	5.12	0.74	5.33	0.94	5.22
	1300	0.57	4.49	0.51	8.53	0.57	12.19	0.57	4.83
	1900	0.45	11.64	0.46	11.64	0.48	12.19	0.50	11.64
26	0100	0.35	11.13	0.51	11.13	0.52	8.00	0.50	10.67
	0700	0.44	11.64	0.49	11.13	0.52	11.13	0.50	10.24
	1300	0.32	8.26	0.51	7.53	0.59	7.11	0.55	6.92
	1900	0.38	10.67	0.46	11.13	0.47	11.13	0.50	8.00
27	0100	0.32	10.24	0.43	11.13	0.45	8.53	0.49	8.83
	0700	0.37	10.67	0.48	10.67	0.47	8.53	0.54	8.53
	1300	0.40	10.67	0.53	10.67	0.56	10.24	0.62	9.48
	1900	0.42	10.67	0.56	11.13	0.60	10.67	0.69	10.24
28	0100	0.51	12.80	0.60	10.24	0.64	10.67	0.69	10.24
	0700	0.49	12.80	0.65	12.19	0.68	12.80	0.74	12.19
	1300	0.48	12.19	0.52	10.67	0.58	12.80	0.62	12.19
	1900	0.43	11.64	0.50	11.13	0.56	12.19	0.64	11.64
29	0100	0.35	11.13	0.50	11.13	0.52	11.13	0.66	5.82
	0700	0.68	5.82	0.81	5.95	0.85	5.95	0.93	6.09
	1300	0.89	6.74	0.93	6.74	0.96	6.56	1.07	6.09
	1900	0.91	6.40	0.97	6.56	0.98	6.24	1.04	6.40
30	0100	0.86	7.53	0.88	7.53	0.96	7.11	1.02	6.92
	0700	0.72	6.24	0.84	8.53	0.88	6.74	0.92	8.53
	1300	0.47	5.95	0.67	7.53	0.68	7.53	0.72	7.53
	1900	0.46	6.40	0.55	8.83	0.59	6.92	0.67	5.82
Mean		0.63	8.29	0.78	8.73	0.82	8.53	0.92	7.85
Std dev		0.36	2.48	0.45	2.03	0.51	1.92	0.53	1.76

* Electronic problems

(Sheet 2 of 2)



PART IV: CURRENT DATA

Current data (Table 4) are collected from a Marsh-McBirney electromagnetic biaxial current meter (Table 1 and Figure 2) and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier 12 m offshore.

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward).

All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the data.

Table 4: Current Data
Apr 1991

Alongshore Cross-shore Resultant Time Day	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter	
	Dye at (579 m) (surface)	Distance from Baseline (m)	Dye 12m offshore (surface)	Location	Speed	Dir	Depth -5.6m (NGVD)	ID #519	Speed	Dir
1 0100-Along Cross Result									12	S
									28	off
									30	93
1 0700-Along Cross Result	32 S 16 off 36 133	165	0 0 0	North	20	S			6	S
									24	off
									25	84
1 1300-Along Cross Result									13	S
									17	off
									21	107
1 1900-Along Cross Result									4	N
									10	off
									11	48
2 0100-Along Cross Result									12	S
									26	off
									29	95
2 0700-Along Cross Result	34 S 12 on 36 179	177	24 S 0 24 160	North	140	S			11	S
									28	off
									30	91
2 1300-Along Cross Result									11	S
									13	off
									17	110
2 1900-Along Cross Result									13	S
									12	off
									18	117
3 0100-Along Cross Result									4	S
									17	off
									17	83
3 0700-Along Cross Result	29 S 7 on 30 174	165	41 S 10 on 42 174	North	26	S			9	S
									21	off
									23	93
3 1300-Along Cross Result									12	S
									22	off
									25	99
3 1900-Along Cross Result									8	S
									19	off
									21	93
4 0100-Along Cross Result									8	S
									13	off
									15	102
4 0700-Along Cross Result	0 5 on 5 250	165	22 N 0 22 340	South	3	N			0	
									5	off
									5	70
4 1300-Along Cross Result									0	
									6	off
									6	70
4 1900-Along Cross Result									4	N
									2	on
									4	313
5 0100-Along Cross Result									4	S
									4	off
									6	115
5 0700-Along Cross Result	38 N 19 off 43 7	201	20 N 6 off 21 357	South	25	N			2	N
									2	on
									3	295
5 1300-Along Cross Result									2	N
									0	
									2	340
5 1900-Along Cross Result									2	N
									8	on
									8	264

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1991

Day	Time	Pier Measurements				Beach Measurements				Current Meter	
		Alongshore Cross-shore Resultant	Dye at (579 m) (surface)	Distance from Baseline (m)	Speed	Dir	Dye at Mid-Surf Zone (surface)	Location	Speed	Dir	0.9 km Offshore Depth -5.6m (NGVD) ID #519
6	0100-Along Cross Result										
		Speed	Dir								
6	0700-Along Cross Result	3	N		23	N		3	S		
		3	off	165	0		North				
		4	25		23	340					
6	1300-Along Cross Result										
6	1900-Along Cross Result										
7	0100-Along Cross Result										
7	0700-Along Cross Result	4	N		23	N		12	N		
		9	off	165	5	off	South				
		10	43		24	351					
7	1300-Along Cross Result										
7	1900-Along Cross Result										
8	0100-Along Cross Result										
8	0700-Along Cross Result	12	N		14	N		8	N		
		12	off	177	17	off	South				
		17	25		22	30					
8	1300-Along Cross Result										
8	1900-Along Cross Result										
9	0100-Along Cross Result										
9	0700-Along Cross Result	22	N		22	N		36	N		
		11	off	189	7	off	South				
		24	7		23	357					
9	1300-Along Cross Result										
9	1900-Along Cross Result										
10	0100-Along Cross Result										
10	0700-Along Cross Result	8	N		13	N		5	N		
		19	off	189	12	off	South				
		20	46		18	22					
10	1300-Along Cross Result										
10	1900-Along Cross Result										

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1991

Alongshore Cross-shore Resultant Time Day	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter	
	Dye at (579 m) (surface)	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir	0.9 km Offshore Depth -5.6m (NGVD) ID #519
11 0100-Along Cross Result										3 6 7
11 0700-Along Cross Result	76 0 76	S off 160	201	102 10 102	S off 154	71	S	13 31 34	S off 93	
11 1300-Along Cross Result										15 53 55
11 1900-Along Cross Result										86 10 33 34
12 0100-Along Cross Result										87 0 4 4
12 0700-Along Cross Result	102 5 102	S on 163	189	55 14 57	S on 174	51	S	1 28 28	S off 72	
12 1300-Along Cross Result										14 22 26
12 1900-Along Cross Result										102 15 34 37
13 0100-Along Cross Result										94 15 22 27
13 0700-Along Cross Result	36 11 37	S on 177	189	44 11 45	S on 174	14	S	9 24 26	S off 91	
13 1300-Along Cross Result										20 23 30
13 1900-Along Cross Result										111 8 13 15
14 0100-Along Cross Result										102 4 7 8
14 0700-Along Cross Result	51 0 51	S off 160	177	20 0 20	S off 160	11	N	3 10 10	S off 87	
14 1300-Along Cross Result										83 34 35
14 1900-Along Cross Result										93 14 33 36
15 0100-Along Cross Result										109 9 11 14
15 0700-Along Cross Result	15 5 16	S off 143	189	27 17 32	S off 127	28	S	3 12 12	S off 84	
15 1300-Along Cross Result										113 13 14 19
15 1900-Along Cross Result										105 3 3 4

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1991

Alongshore Cross-shore Resultant Time Day	Pier Measurements			Beach Measurements (500m Updrift)			Current Meter		
	Dye at (579 m) (surface)	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir
16 0100-Along Cross Result								3	S
								4	on
								5	213
16 0700-Along Cross Result	0		177	0			North	13	N
	0	0		0	0			1	off
								1	25
16 1300-Along Cross Result								0	
								22	off
								22	70
16 1900-Along Cross Result								1	S
								0	
								1	160
17 0100-Along Cross Result								2	S
								4	off
								4	97
17 0700-Along Cross Result	15	N		15	N			8	N
	4	off	177	0				2	on
	15	354		15	340			8	326
17 1300-Along Cross Result								4	S
								5	off
								6	109
17 1900-Along Cross Result								1	S
								6	on
								6	241
18 0100-Along Cross Result								2	S
								4	off
								4	97
18 0700-Along Cross Result	36	S		47	S			9	S
	0		165	0				20	off
	36	160		47	160			22	94
18 1300-Along Cross Result								19	S
								43	off
								47	94
18 1900-Along Cross Result								15	S
								31	off
								34	96
19 0100-Along Cross Result								20	S
								41	off
								46	96
19 0700-Along Cross Result	44	S		87	S			17	S
	13	on	213	26	on			34	off
	45	177		91	177			38	97
19 1300-Along Cross Result								14	S
								36	off
								39	91
19 1900-Along Cross Result								9	S
								23	off
								25	91
20 0100-Along Cross Result								13	S
								25	off
								28	97
20 0700-Along Cross Result	0			68	N			7	S
	5	on	201	17	on			24	off
	5	250		70	326			25	86
20 1300-Along Cross Result								11	S
								33	off
								35	88
20 1900-Along Cross Result								36	S
								80	off
								88	94

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on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1991

Alongshore Cross-shore Resultant Time Day	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter	
	Dye at (579 m) (surface)	Distance from Baseline (m)	Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)		0.9 km Offshore Depth -5.6m (NGVD) ID #519			
	Speed	Dir	Speed	Dir	Location	Speed	Dir	Speed	Dir	
21 0100-Along Cross Result								26	S	
								38	off	
								46	104	
21 0700-Along Cross Result	55	S	189	102	S	53	S	25	S	
	0			30	off			39	off	
	55	160		106	143	North		46	103	
21 1300-Along Cross Result								19	S	
								25	off	
								31	107	
21 1900-Along Cross Result								14	S	
								20	off	
								24	105	
22 0100-Along Cross Result								5	S	
								1	on	
								5	171	
22 0700-Along Cross Result	9	S		15	S			1	S	
	14	off	177	4	off	no observation		3	on	
	17	104		15	143			3	232	
22 1300-Along Cross Result								10	N	
								17	on	
								20	280	
22 1900-Along Cross Result								1	S	
								10	on	
								10	244	
23 0100-Along Cross Result								1	N	
								11	on	
								11	255	
23 0700-Along Cross Result	9	N		8	N	5	N	4	N	
	0		189	8	off			0		
	9	340		11	25	South		4	340	
23 1300-Along Cross Result								2	S	
								2	off	
								3	115	
23 1900-Along Cross Result								6	S	
								7	off	
								9	111	
24 0100-Along Cross Result								10	N	
								12	on	
								16	290	
24 0700-Along Cross Result	38	N		5	N	15	N	1	N	
	6	off	177	2	off	South		1	off	
	39	349		5	357			1	25	
24 1300-Along Cross Result								4	N	
								1	on	
								4	326	
24 1900-Along Cross Result								1	S	
								7	off	
								7	78	
25 0100-Along Cross Result								16	S	
								32	off	
								36	97	
25 0700-Along Cross Result	47	S		47	S	44	S	11	S	
	0		177	5	off			28	off	
	47	160		47	154	North		30	91	
25 1300-Along Cross Result								8	S	
								23	off	
								24	89	
25 1900-Along Cross Result								9	S	
								22	off	
								24	92	

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Concluded)
Apr 1991

Day	Time	Pier Measurements				Beach Measurements			Current Meter		
		Dye at (579 m) (surface)	Speed	Dir	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed
26	0100-Along Cross Result										0.9 km Offshore Depth -5.6m (NGVD) ID #519
26	0700-Along Cross Result	34 0 34	S 160		165	0 0			5 N South	24 13 14	off S 91
26	1300-Along Cross Result										5 S 21 off 22 83
26	1900-Along Cross Result										9 S 18 off 20 97
27	0100-Along Cross Result										2 S 8 off 8 84
27	0700-Along Cross Result	5 5 8	N off 25		165	11 3 357	N off 357		11 N South	2 1 2	N on 313
27	1300-Along Cross Result										0 1 on 1 250
27	1900-Along Cross Result										2 N 3 on 4 284
28	0100-Along Cross Result										7 N 13 on 15 278
28	0700-Along Cross Result	51 0 51	N off 340		165	10 0 10	N off 340		1 N South	0 3 3	on 250
28	1300-Along Cross Result										3 N 2 on 4 306
28	1900-Along Cross Result										3 S 2 off 4 126
29	0100-Along Cross Result										6 S 15 off 16 92
29	0700-Along Cross Result	87 4 87	S off 157		177	0 0 0			1 N North	12 20 23	S off 101
29	1300-Along Cross Result										4 S 15 off 16 85
29	1900-Along Cross Result										8 S 19 off 21 93
30	0100-Along Cross Result										7 S 13 off 15 98
30	0700-Along Cross Result	7 2 7	N off 354		177	0 0 0			13 S North	6 13 14	S off 95
30	1300-Along Cross Result										10 S 9 off 13 118
30	1900-Along Cross Result										5 S 2 off 5 138

KEY = All speeds in cm/sec
 N = Northward, Shore parallel
 S = Southward, Shore parallel
 on = onshore off = offshore

PART V: SUPPLEMENTAL OBSERVATIONS

Visual wave direction measurements (Table 5) of both the primary wave train (i.e. that having the larger wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is orientated 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A jar along with a thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The jar is removed, the temperature read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the surface visibility.

Table 5: Supplemental Observations

Apr 1991

Day	Time	Wave Approach		Radar Wave Angle deg from True N	Width of Surf Zone.m	Water Characteristics at Pier End		
		Primary	Secondary			Temp.,C	Density g/cc	Secchi Vis.,m
1	0817	60			136	10.6	1.0204	0.9
2	0804	50	30	55	39	10.8	1.0200	2.7
3	0758	50	15	60	30	10.8	1.0200	2.4
4	0820	90		100	8	11.1	1.0180	2.4
5	0805	100			12	11.1	1.0202	2.7
6	0914	75		inoperative	12	10.0	1.0250	2.7
7	0648	95		inoperative	15	10.0	1.0246	3.4
8	0737	120			7	10.6	1.0249	2.1
9	0740	100		95	16	11.1	1.0248	3.4
10	0737	130			15	11.1	1.0248	3.0
11	0742	35	10	25	193	10.6	1.0256	1.2
12	0739	35	10		24	13.9	1.0188	
13	0721	50	30	35	37	13.3	1.0202	1.8
14	0810	100	15	90	24	12.2	1.0230	3.4
15	0733	55	25		152	13.3	1.0216	2.1
16	0714	110			24	12.2	1.0242	2.4
17	0706	115			18	15.6	1.0214	3.0
18	0646	20		35	46	12.8	1.0232	
19	0736	45	10	45	192	13.3	1.0208	1.5
20	0852	70	20	60	211	13.9	1.0206	
21	0750	55	5	65	189	12.2	1.0210	0.3
22	0738	50			24	12.2	1.0220	0.6
23	0730	100			18	12.2	1.0226	0.9
24	0741	115			23	12.8	1.0224	0.9
25	0743	35	10	55	14	13.3	1.0220	1.2
26	0722	100	125		20	13.9	1.0200	2.4
27	0658	100			13	15.6	1.0208	2.1
28	0752	90	115		18	13.9	1.0220	2.4
29	0731	100	20		22	14.4	1.0218	2.7
30	0709	55	100		16	16.7	1.0196	2.1

PART VI: WATER LEVELS

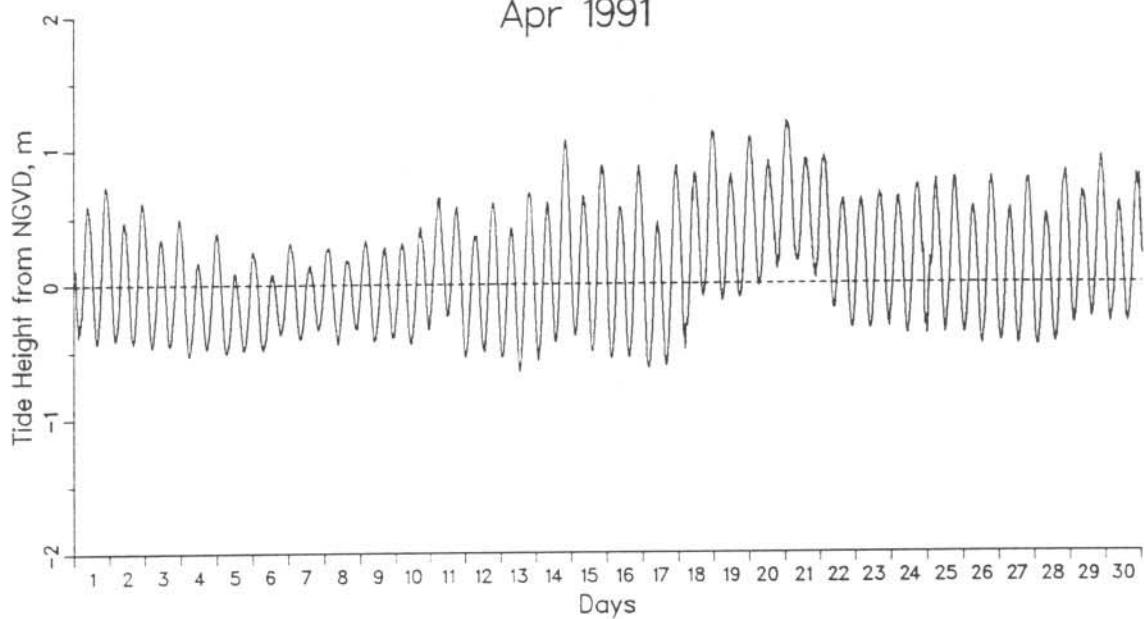
Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gage is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 4 along with a list of mean and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 6 contains the time at the center of each 12.42-hr tidal cycle and the range, high, low, and mean water levels during each tidal cycle.

FRF Tide Heights

Apr 1991



Monthly Water Levels, m NGVD

Extreme Low = -0.66 on day 13 at 1142 EST
Extreme High = 1.21 on day 20 at 2342 EST
Monthly Mean = 0.12
Mean Low = -0.38
Mean High = 0.62
Mean Range = 0.99

Table 6: Water Levels.m NGVD

		Apr 1991			
Day	Mid-Cycle Time	Low	High	Mean	Range
1	512	-0.39	0.60	0.10	0.99
1	1737	-0.44	0.74	0.15	1.18
2	602	-0.41	0.48	0.02	0.89
2	1827	-0.44	0.62	0.10	1.06
3	652	-0.47	0.35	-0.07	0.81
3	1918	-0.46	0.50	0.01	0.95
4	743	-0.53	0.17	-0.19	0.70
4	2008	-0.48	0.39	-0.04	0.87
5	833	-0.51	0.09	-0.23	0.60
5	2058	-0.49	0.25	-0.12	0.74
6	924	-0.49	0.09	-0.20	0.57
6	2149	-0.37	0.32	-0.02	0.68
7	1014	-0.40	0.15	-0.12	0.55
7	2239	-0.33	0.28	-0.02	0.61
8	1104	-0.44	0.19	-0.10	0.62
8	2330	-0.33	0.34	0.00	0.66
9	1155	-0.42	0.28	-0.07	0.70
10	20	-0.39	0.32	-0.04	0.71
10	1245	-0.45	0.44	-0.01	0.88
11	110	-0.33	0.65	0.17	0.98
11	1336	-0.24	0.58	0.15	0.82
12	201	-0.54	0.36	-0.06	0.91
12	1426	-0.50	0.61	0.06	1.11
13	251	-0.54	0.42	-0.07	0.97
13	1516	-0.66	0.69	0.05	1.34
14	342	-0.57	0.61	0.03	1.18
14	1607	-0.43	1.07	0.35	1.50
15	432	-0.38	0.66	0.12	1.04
15	1657	-0.50	0.88	0.22	1.39
16	522	-0.55	0.58	0.01	1.13
16	1747	-0.54	0.88	0.16	1.42
17	613	-0.63	0.46	-0.11	1.09
17	1838	-0.61	0.88	0.19	1.49
18	703	-0.49	0.83	0.23	1.32
18	1928	-0.10	1.13	0.53	1.23
19	753	-0.12	0.81	0.33	0.94
19	2019	-0.10	1.09	0.50	1.19
20	844	-0.02	0.91	0.45	0.93
20	2109	0.11	1.21	0.70	1.10
21	934	0.17	0.93	0.54	0.76
21	2159	0.03	0.96	0.50	0.92
22	1025	-0.18	0.63	0.23	0.81
22	2250	-0.33	0.64	0.16	0.97
23	1115	-0.34	0.69	0.18	1.02
23	2340	-0.32	0.65	0.18	0.97
24	1205	-0.37	0.74	0.20	1.11
25	31	-0.38	0.78	0.24	1.16
25	1256	-0.37	0.79	0.21	1.16
26	121	-0.37	0.58	0.10	0.94
26	1346	-0.45	0.79	0.16	1.24
27	211	-0.43	0.56	0.06	0.99
27	1437	-0.46	0.78	0.17	1.24
28	302	-0.47	0.52	0.03	0.98
28	1527	-0.44	0.84	0.20	1.28
29	352	-0.30	0.69	0.21	0.98
29	1617	-0.26	0.94	0.34	1.20
30	443	-0.30	0.61	0.14	0.90
30	1708	-0.29	0.81	0.26	1.10

PART VII: NEARSHORE PROFILES

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Zeiss surveying system; a Zeiss Elta-2 first-order, self-recording electronic theodolite distance meter in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 5 shows the last survey in March and the only survey in April on profile line 188, located 517 m south of the pier. Changes include a 40 m shoreward shift in the nearshore bar (160 - 280 m) and a 1 m deepening of the nearshore trough (140 - 200 m). Only minor changes are visible on the remainder of the profile.

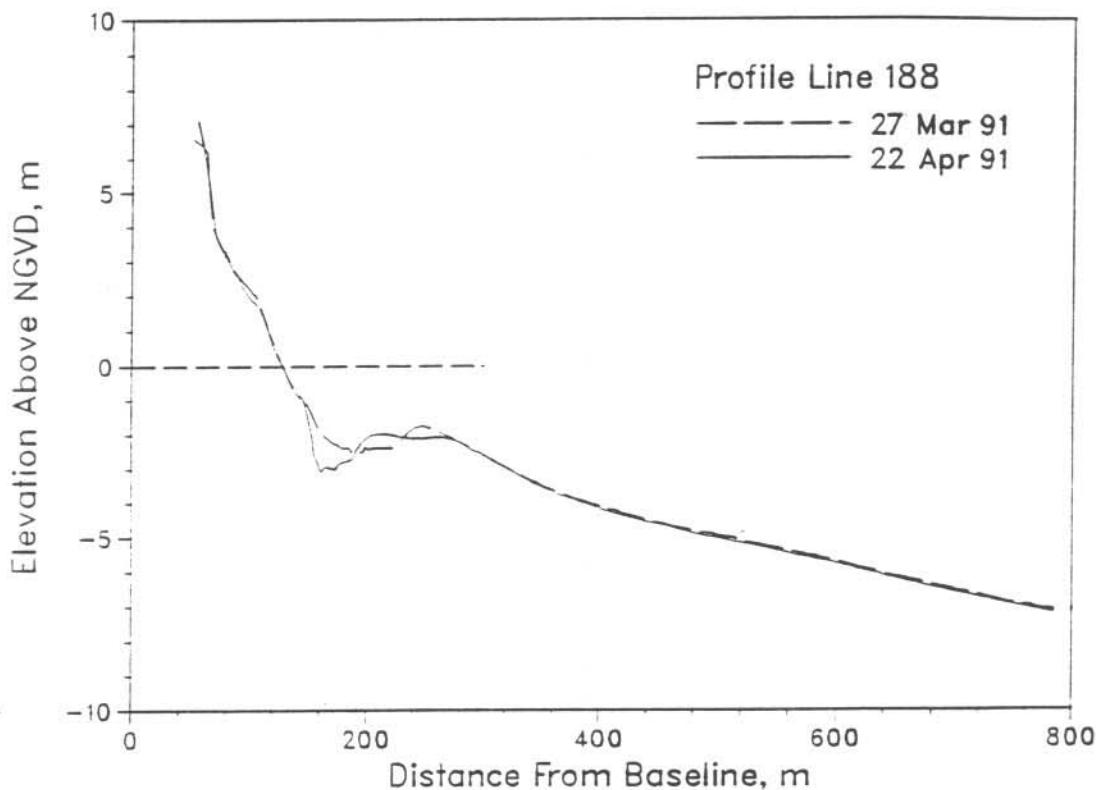


Figure 5. Monthly CRAB profiles on profile 188 - 517 m south of pier.

The profile envelope (Figure 6) reflects the maximum changes that occurred on the profile during 1991. The shoreward migration of the nearshore bar and the deepening of the nearshore trough are responsible for the changes to the envelope.

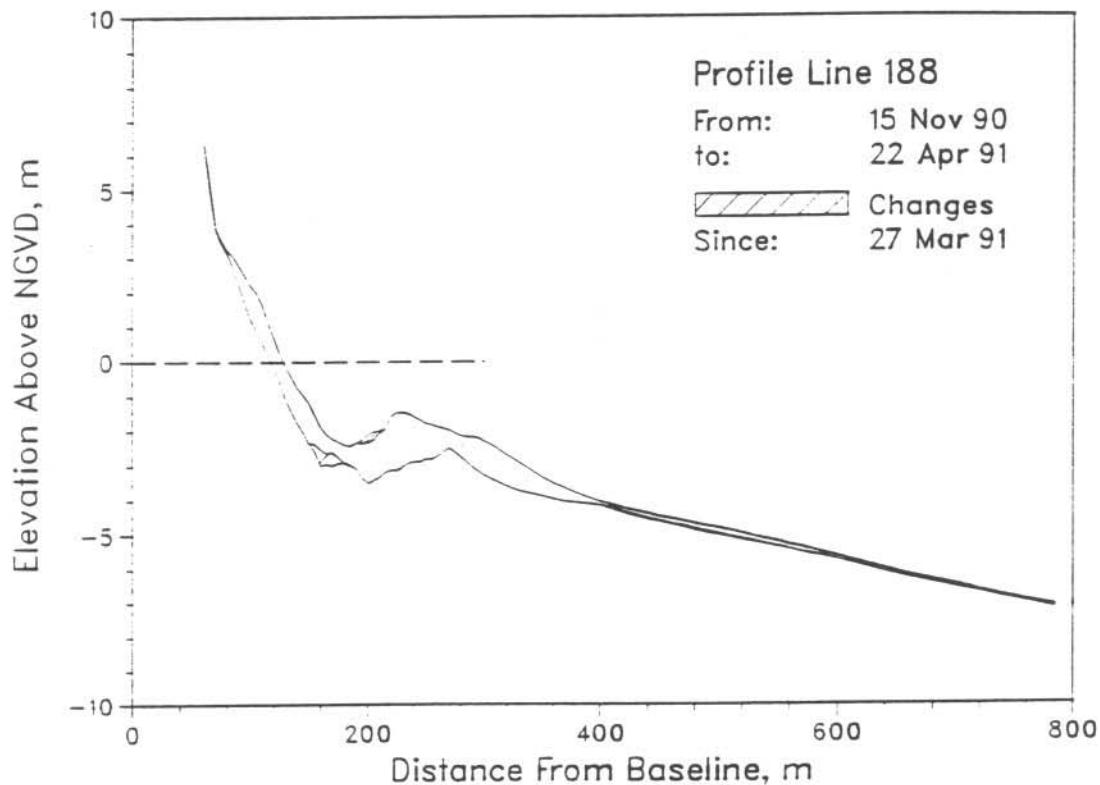


Figure 6. CRAB profile envelope - profile 188.

B. Bathymetry. Figure 7 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 22 April. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

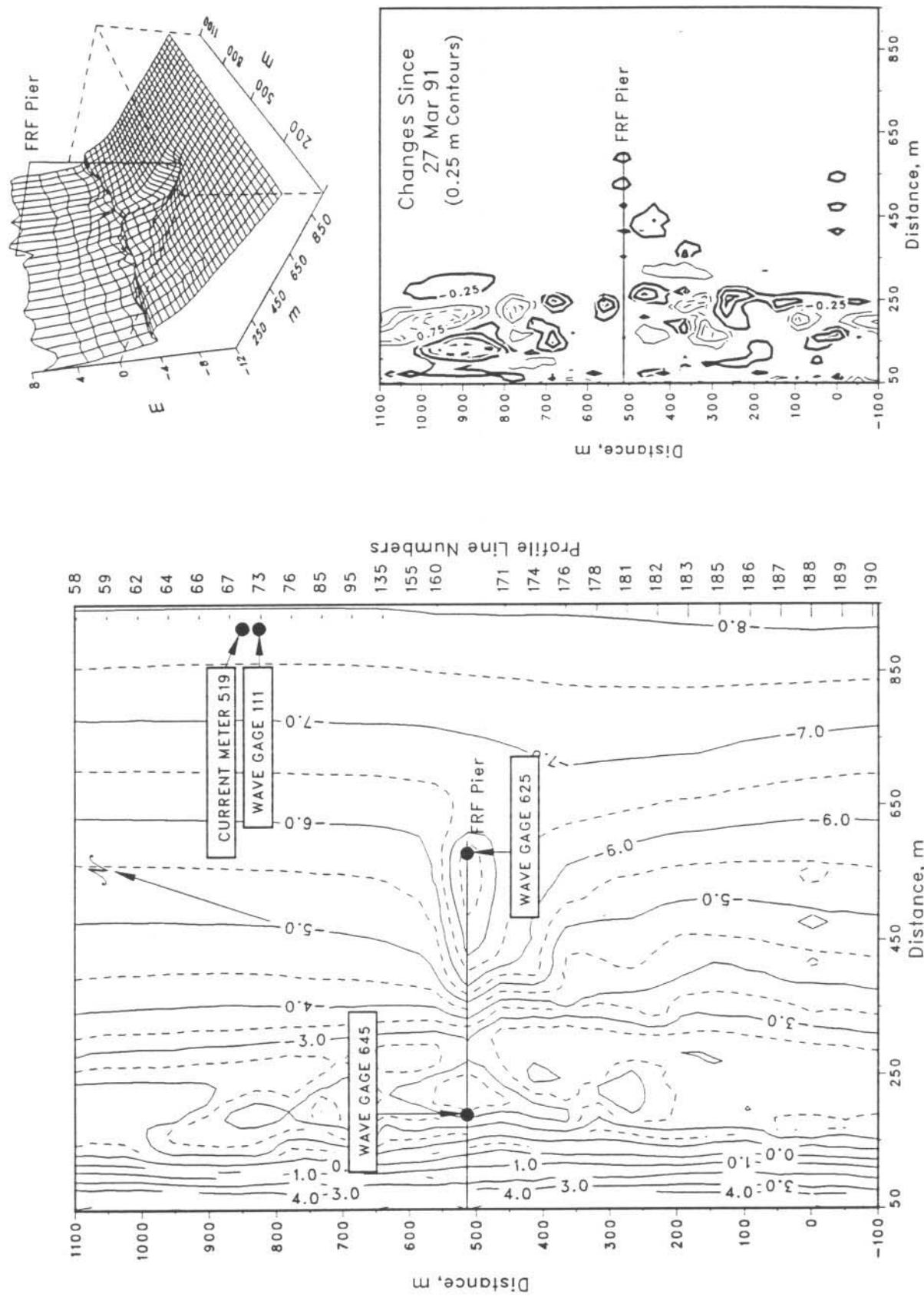


Figure 8. FRF bathymetry 22 Apr 91 depths relative to NGVD

VIII. SPECIAL EVENTS

A. Storm Data Collection. The following list identifies times when the significant wave height at the seaward end of the pier (i.e. as measured at the end of the pier) exceeded 2 m and four contiguous 34 minute wave records were obtained every 3 hours.

<u>Start</u>	<u>End</u>
20 Apr (0808)	21 Apr (0316)

B. Storm Synopsis.

20-21 April - Developing off Cape Hatteras, NC on 20 April this intense coastal storm quickly deepened and moved up the coast being located off the Maryland coast early on 21 April and over Canada by 22 April. Maximum wind speeds near 17 m/s (from north-northeast) were recorded at 1600 EST on 20 April with the maximum H_{mo} (at gage 625) of 2.81 m ($T_p = 8.83$ sec) occurring several hours later at 2020 EST. This was followed the next morning at 0208 EST by the minimum atmospheric pressure of 998.4 mb. Total precipitation at the FRF from this system was 42 mm.

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